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Flooding Induced Occurrence of Terrestrial Nematode Species and Genera in the Benthos of River Nun, Niger Delta

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Authors' contributions

This work was carried out in collaboration between all authors. Author SON designed and coordinated the research. Authors AOU and TBB collected the samples and produced the draft while author HOI identified the Nematodes*. All authors read and approved the final manuscript.*

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ABSTRACT

Aims: To investigate; the effects of flooding and dredging on the nematode community composition in River Nun, Niger Delta, Nigeria.
Study Design: The study is a survey using River Nun as a case study.
Place and Duration of Study: Study area is a section of River Nun in Bayelsa State, Niger Delta, Nigeria, Samples were collected for 30 days.
Methodology: Eckmann's grab was used in collecting samples at depths; 0-10cm and 10-20cm from nine designated collection points (A_x – G_x) along the river course. Nematodes were extracted from the sediment by the use of the modified Baermann's extraction method. Identification was by

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the use of the binocular light microscope and standard guides. Physicochemical parameters were determined using handheld water checkers. Data was analysed using Measures of Central Tendency, ANOVA and Species Diversity Index (SDI).

Results: The study revealed that the physicochemical parameters considered in the study did not deviate from the standard permissible in freshwater ecosystems despite the persistent flooding and dredging of the water way. Species abundance and diversity revealed seven (7) nematode species and genera from six (6) families amounting to a total of 46 nematodes. There was variability in vertical distribution and speciation in the study. Data showed the following speciation and abundance; *Tylenchus filiformis,* 14 (31.0%); *Ditylenchus* spp., 2 (4.0%)*, Pratylenchus pratensis* 18 (39.0%)*, Longidorus* spp., 2 (4.0%); *Tylenchorhynchus dubius,* 2 (4.0%); *Criconema* spp., 2 (4.0%) and *Meloidogyne* spp., 6 (13.0%). Depth related prevalence indicated a preference of nematodes to the top trophic level with the 0-10cm having the highest number (30 individuals) of nematode and the 10-20cm depth having a total of (16) nematodes. There was no statistical difference ($P \leq 0.3$) in nematode occurrence between the two depths. SDI showed that the nematode species diversity in River Nun was relatively high (0.76). Also data showed that sediment soil typology influenced the occurrence of nematodes in the study with all the recorded nematodes occurring in the sandy sediment in contrast to clayey and silty sediment where no nematodes were recorded.

Conclusion: The study revealed a colonization of the sediment by terrestrial nematode species and genera due to the persistent flooding experienced in the area which has converted the freshwater ecosystem to a depository of debris and other suspended particles that come in with the run-off water from the hinterlands. The absence of aquatic species of nematodes in the studied samples is also attributed to the aggressive dredging in the habitat that may have altered the bottom substrate, washed away the native nematode fauna making re-establishment of new aquatic nematode community difficult as a result of increased current. The study concludes that the affiliation of nematodes to sandy sediment is due to increased aeration and availability of food which guarantees the survival of other organisms.

Keywords: Nematode species and genera abundance and diversity; vertical distribution; top trophic level; colonization of terrestrial species; increased aeration.

1. INTRODUCTION

Nematodes; the most numerous of all Metazoa in number of individuals, exist in all habitats that can support life [1]. They are unsegmented, cylindrical, elongated, tapered at both ends and may be free-living or parasitic [2,3]. Nematodes are abundant constituting about 15% of the total biomass in freshwater lake bottoms with the Order Dorylaimida the most successful in terms of abundance and geographical distribution. Nematodes play an important role in the maintenance of the complex aquatic ecosystem energy flow and trophic organization in the food web. Some feed on plants such as algae (first trophic level); others are grazers that feed on bacteria and fungi (second trophic level); and some feed on other nematodes (higher trophic levels) [4,5].

Warwick [6] and Chen et al. [7] in their studies identified nematodes as good bio-indicators of pollution, due to their relative abundance, relatively stationary life habits, short generation time, existence of benthic larvae and their close association with sediment that accumulate numerous contaminants. Buttressing the relevance of nematodes as bio-indicators, Quadsia, [1] demonstrated the ability of aquatic forms of nematodes to withstand various stresses by undergoing cryobiosis, osmobiosis, anoxybiosis and throbosis involving sulphide detoxification mechanism. This physiological dynamism observed in the nematode ensures its survival in harsh environmental conditions occasioned by natural or allochthonous conditions.

1.1 Nematodes in the Aquatic Environment

Free-living nematodes; usually found in moist soil and bodies of fresh water are mostly less than a millimetre in length. Interestingly, two-fifth of the nematode families representing about one-fifth of the 1,800 recorded genera are domicile in freshwater habitats [8]. The adaptive flexibility observed in the Order Dorylaimida accentuates its extra ordinary ecological success in freshwater ecosystems. On the other hand, members of the subclass; Enoplia, are principally marine nematodes but include some exclusively freshwater taxa with extreme endemism. Objectively, the ubiquitous distribution of nematodes especially in limnetic conditions and habitats with unfriendly ecological characteristics that naturally inhibit the survival of other meiobenthic invertebrates should project their significance in environmental evaluation studies. Sadly, this envisaged relevance of nematode assemblages in the determination of the health status of a specific biota has not been achieved due to the intricacies associated with the extraction, isolation and identification of these worms.

Studies on freshwater nematodes species show extreme regional bias with the southern hemisphere affiliated forms being extremely underrepresented when juxtaposed with European freshwater bodies [9,10]. This could be due to scanty documentation of research works relating to the usefulness of nematodes in environmental assessments or lack of expertise in the field of study; nematology. On the other hand, majority of recorded cases have been from single bio-geographic regions. Studies by Decraemer and Coomans [8], Lambshead [9], Decraemer and Smol [10] and Eyualem et al. [11] had shown that nematodes in the Orders Monhysterida and Plectida and subclass Chromadoria constitute half of the freshwater nematodes due to their wide geographic specificity. The population density of nematodes in some marine sediment may reach as much as 20 million per square metre which is hardly recorded in freshwater bodies' however research had showed that any sample taken from the debris of a pond bottom will contain numerous specimens [12].

1.2 Influence of Anthropogenic Factors on the Environment

Several studies have implicated anthropogenic factors such as agriculture, industrialization, mining, etc as key determinants of floral and faunal perpetuation in the environment. This is true in the case of the Niger Delta where poor regulations in the exploitation of natural reserves such sand mining (dredging), deforestation, unsustainable fishing, petroleum bunkering excessive wild life harvesting have left a toll on the environment and its inhabitants. Again, the geographical characteristics of the study area contributes to the depreciation of its ecological integrity which manifests in the forms loss biodiversity, sheet and rill erosion, pollution of the terrestrial and aquatic environment and persistent flooding [13].

The pivotal role of nematode assemblage in aquatic and terrestrial habitats cannot be over emphasized in environmental evaluation studies. They serve as a link between the micro- and macro-organisms in the environment due to their vital role in nutrient cycling [2,7,14]. Unfortunately, the adoption of nematodes by environmentalists as a key element in data collection and analysis in environmental impact assessment studies is generally haphazard and totally missing in Africa and Nigeria in particular. Lack of awareness of the significance of nematode assemblages in the determination of the health status of a specific biota and scarcity of expertise in the discipline; nematology had been implicated for this situation in Nigeria. This study is aimed at determining the effects of flooding and dredging on the aquatic nematode community composition in River Nun, Niger Delta, Nigeria.

2. MATERIALS AND METHODS

2.1 Study Area

The study area was a section of the course of River Nun in Kolokuma, Opokuma L.G.A, Bayelsa State in the Niger Delta region of Nigeria. The river is 160km in length and has a very swift current. It has a muddy colouration and has been subjected to dredging recently to reduce silt deposition. River Nun is a receptacle for the numerous flood rills that deposit numerous debris and dissolved substances from farms and factories form the hinterland. The river is a source of sand for construction activities, fish and shellfish for both personal and commercial needs, water for domestic uses, means of transportation and also a source of recreational activities for the surrounding communities.

2.2 Collection of Samples

2.2.1 Designation of sampling station

The collection points consisted of nine (9) selected sampling points of 0-10cm and 10-20cm of bottom sediment in the river. The sampling points were designated as follows:

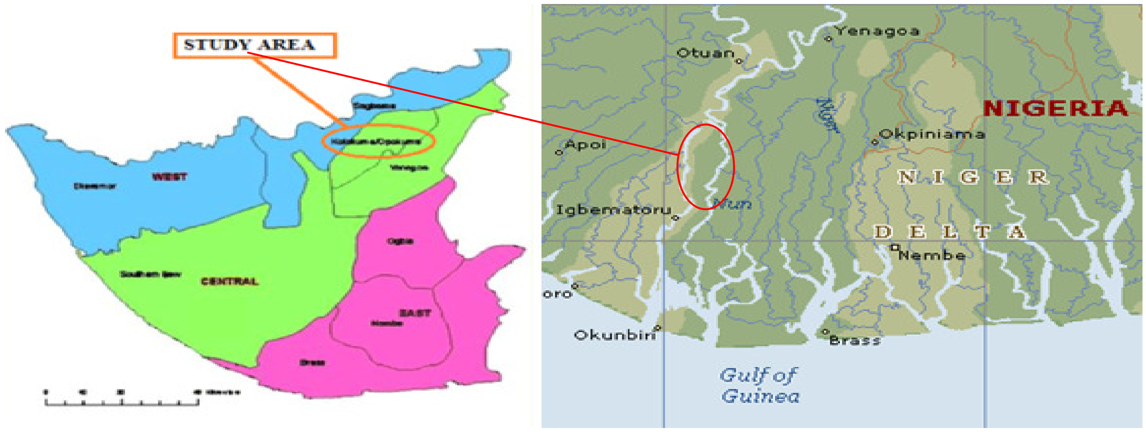

Fig. 2.1. Maps of the Niger Delta showing the study Area

2.2.2 Station 1; Soil type: clay. Location: longitude 6°16'35.73"E and latitude 5°04'32.67"N

1a) Core A1 (0-10cm) 1b) Core A2 (10-20cm)
2a) Core B1 (0-10cm) 2b) Core B2 (10-20cm)
3a) Core C1 (0-10cm) 3b) Core C2 (10-20cm)

2.2.3 Station 2; Soil Type: clay/silt. Location: longitude 6°16'32.46"E and latitude 5°04'33.58"N

4a) Core D1 (0-10cm) 4b) Core D2 (10-20cm)
5a) Core E1 (0-10cm) 5b) Core E2 (10-20cm)
6a) Core F1 (0-10cm) 6b) Core F2 (10-20cm)

2.2.4 Station 3; Soil Type: sandy. Location: Longitude 6°16'42.82"E and latitude 5°04'29.42"N

7a) Core G1 (0-10cm) 7b) Core G2 (10-20cm)
8a) Core H1 (0-10cm) 8b) Core H2 (10-20cm)
9a) Core I1 (0-10cm) 9b) Core I2 (10-20cm)

The depths (0-10cm and 10-20cm) were carefully marked on the body of the dredge for easy identification. The Eckman's dredge of 6" x 6" x 6" stainless steel was used to collect bottom sediment aboard a boat anchored at desired points in the river [15]. Nine (9) cores at depths 0-10cm and 10-20cm were collected in properly labelled containers and taken to the laboratory for nematode extraction, isolation and identification.

2.3 Nematode Extraction

The modified Baermann's method as modified by Nzeako et al. [16] was used to extract the nematodes from the sediments. Sediments from each core (A-I) were properly mixed individually to eliminate spatial concentration of nematodes. Ten (10) sub-samples were derived from the uniform samples and set up for extraction. The extraction fluid (20ml of tap water) was activated with 1ml of Hydrogen peroxide (H_2O_2) at 12 hour intervals for enhanced aeration and allowed to stand for 48hours under room temperature. After which the nematode aliquots were decanted and the supernatant fixed with 0.4% formalin and stored in properly designated universal sample bottles for onward counting and identification.

2.4 Microscopic Examination

Nematodes were identified using the Light compound microscope according to Golden [17] and identified according to the guide by Goodey [18].

2.5 Physicochemical Parameters Determination

Five (5) parameters were determined using handheld electronic water checkers (Martini Instrument, model: MI 806 and Milwaukee DO meter). The parameters determined include: dissolved oxygen (DO - mg/L), salinity ($^{0}/_{00}$), conductivity (ms/m), temperature (°C) and pH.

2.6 Data Statistical Analysis

Measures of Central Tendency, Simpson's Species Diversity Index (SDI) and ANOVA were used for analysis of the data.

3. RESULTS AND DISCUSSION

3.1 Physicochemical Parameters of River Nun

Table 3.1 shows the physicochemical parameters of River Nun. Data revealed that four physicochemical parameters; DO, 4.9-5.4mg/L; salinity, 0.05°/∞; temperature, 22.3-22.6℃ and pH 6.87-7.07 out of the five considered were within the normal range except conductivity 0.09-0.10 ms/m, which was slightly above the standard permissible in freshwater ecosystem. This result indicates a depository effect of flooding on the water body under study.

3.2 Nematode Population at Various Sampling Points and Depths in River Nun

The spatial distribution of benthic nematodes in terms of abundance and species richness varied drastically in the study. The observed variability was associated with the sediment soil type. Sandy soil accounted for all recovered nematodes with core designation (G-I) having a total of 46 nematodes of various species (Table 3.2). The 0-10cm sediment core accounted for 65.21% of the overall extracted nematodes while the 10-20cm sediment depth had 34.78% of the recovered worms.

3.3 Nematode Speciation and Population in River Nun

A total of seven (7) species and genera of nematode were recovered from the examined sediment samples. Data shows vertical distribution of nematodes that favoured upper trophic level dwellers. At sampling depth 0-10cm, a total population of 30 nematodes were observed and the highest occurring nematode species was *P. pratensis;* 13 (43.3%), *Tylenchus. filiformis* had a total of 8(26.7%); while *Ditylenchus* spp., *Longidorus sp., Tylenchorynchus dubius* and *Meloidogyne sp.* all had occurrences of 2 (6.7%) each. *Criconema* spp. a species rarely seen in freshwater habits recorded a total of 1 (3.3%). The study also revealed the concentration of terrestrial nematodes species which are usually plant parasitic at certain stages of their life cycles (Fig. 3.1).

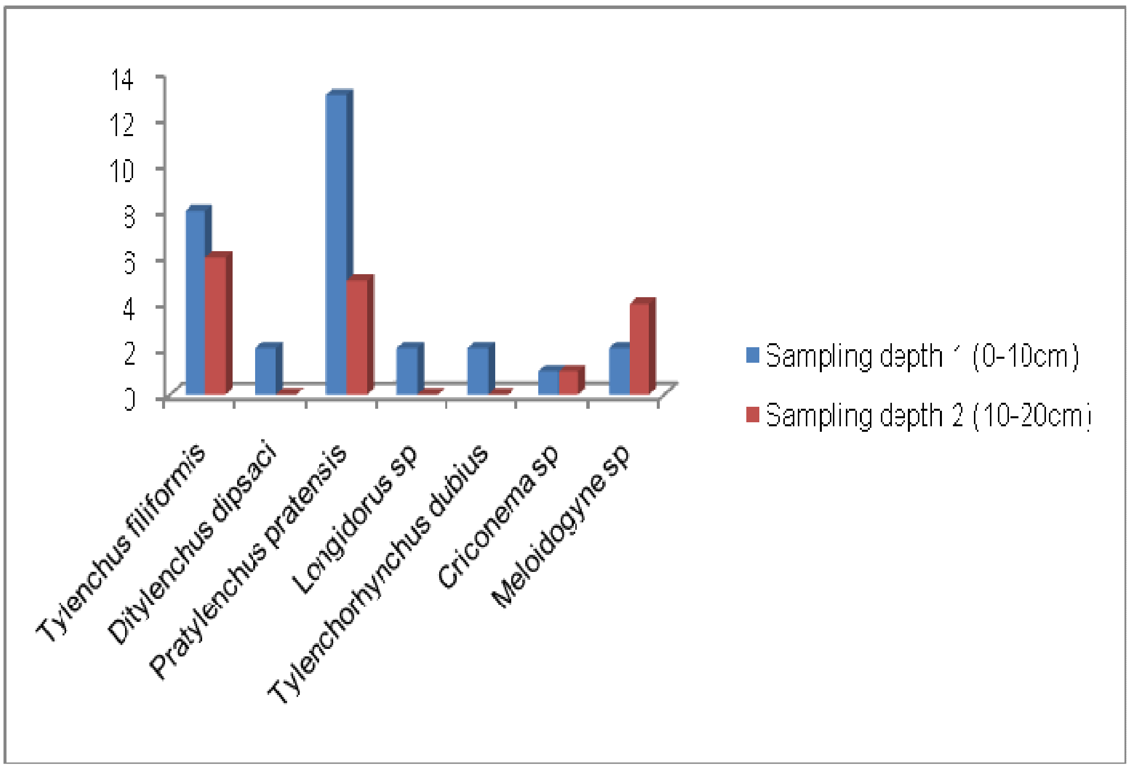

Fig. 3.1. Nematode population at different sampling depths

Table 3.1. Physicochemical parameters of River Nun

Core designation	Dissolved oxygen (mg/l)	Salinity (°/◦◦)	Conductivity (ms/m)	temperature (°C)	ph
A	5.42± 0.16	0.05±0.00	0.13±0.01	22.32±0.10	7.07±0.06
B	4.94± 0.16	0.05±0.00	0.09±0.01	22.41±0.10	6.92±0.06
C	5.42± 0.16	0.05±0.00	0.12±0.01	22.62±0.10	6.87±0.06
Mean	5.26± 0.16	0.05±0.00	0.11±0.01	22.46±0.10	6.95±0.06

**Acceptable levels: Temperature (NA); pH (6.5-8.5); DO (0-20); Salinity (0.05); Conductivity (0.001-0.3) [19,20]*

Table 3.2. Nematode population at various sampling points and depths in River Nun

Core depths (cm)	Sampling core/Designation (%)									Overall pop. of nematodes (%)
	A	B	C	D	E	F	G	H	I	
0-10	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	12 (40.0)	10(33.3)	8(26.7)	30(65.21)
10-20	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	1(6.3)	11(68.8)	4(25.0)	16(34.78)
Overall pop. of nematodes at different depths (%)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	0(0.0)	13(27.08)	21(45.65)	12(26.08)	46
Dominant Soil type in sediment	CLAY			CLAY/SILT			SAND			

3.5 Discussion

The spatial distribution in terms of species and genera richness and abundance varied drastically across the sampling points. The spatial distribution of benthic nematodes in the study was associated to soil typology with the clay and silt harbouring no nematodes while great abundance and specificity was recorded in the sandy soil dominated sediment (Table 3.2). This observation is in accordance with studies by Bart et al. [21] and Vanavertbeke et al. [22], where more nematodes were found in sandy soil and loamy soil than in clay or silt. In this study it is inferred that the abundant population of nematodes in the sandy soil may be due to the good aeration and porosity of the soil type which promote meio-faunal survival in aquatic ecosystems [2]. We also envisaged that the persistent flooding in the area and the position of the Nun River as a receptacle for run-off water from the hinterland may have caused the death of nematodes in the clay/silt soil types due to sedimentation of dissolved particulates that further seal the channels of air flow at the bottom niches. This opinion is supported by the relatively high conductivity recorded in the study (Table 3.1).

A total of seven (7) nematode species and genera amounting to 46 nematodes from six (6) families were extracted from the 180 sediment samples examined; *Tylenchus filiformis* 14 (31.0%), *Ditylenchus* spp 2 (4.0%), *Pratylenchus pratensis* 18 (39.0%), *Longidorus* spp 2 (4.0%), *Tylenchorhynchus dubius* 2 (4.0%), *Criconema* spp 2 (4.0%) and *Meloidogyne* spp 6 (13.0%) (Fig. 3.1). The aforementioned species had different occurrences at different depths. Depth 0-10cm had the highest (30) nematode species occurrence while depths 10-20cm had the least (16) nematode species occurrence. The population density of nematodes at the top trophic level is a normal pattern of dispersion in aerobic communities of meio-fuana where oxygen dependent members of the community are usually top browsers. The observed vertical distribution of organisms in the study was not statistically significant ($p>0.05$) and may be associated with food availability. According to Eyualem [12] nematodes such as *Paratylenchus* spp, *Tylenchida* spp and *Aphelenchoides* spp. usually occurred more in the upper strata of any habitat they are found. [23, 24,25] in their studies, stated that the trophic strata preferred by a specific nematode in various environmental water/sediment/soil conditions are determined by the available food chains that will ultimately sustain other animals. They inferred that these food sources are the main catalyst of some water/sediment/soil processes, especially mineralization and humification of decomposed organic matter, responsible for cycling of sediment/soil nutrients and self-purification of water; due to their interaction with bacteria, algae and fungi.

It was observed that majority of the nematodes isolated from the sediment were semi-endo plant parasitic terrestrial species (Fig. 3.1). This is a very interesting situation because it portrays the occurrence of novel species believed to be free living terrestrial and plant parasitic nematodes in aquatic habitat. The persistent flooding of the region and aggressive dredging of the River are implicated for this situation. Dredging of any water way increases the current of such water body. In this study, we assume that increased water current due to dredging and flooding contributed greatly to the reduction in the native nematode species in the river. River portions close to vegetation had nematode populations that are more or less terrestrial (Plate 1.0). This is also in tune with studies by Simonini et al. [26], Newell et al. [27], Desprez [28] and Abam [29]; where nematode community changed drastically during dredging periods. There was a shift towards larvae stages of the nematodes as observed from the nematode spectra. However, the species diversity index (Simpson's index of diversity) showed that the species and genera diversity of nematodes in River Nun was high (0.76). Furthermore, the river's dredging over time has deepened it, causing higher flow velocity and the river has also been recently subjected to flooding [30]. This has affected the benthic community of the river and its swift water current has made it difficult for easy re-colonization of the entire river course by its normal fauna. The physicochemical parameters (Table 3.1*) were within the range of a healthy fresh water body as observed in guidelines provided by EPA, [30]; and ANZECC and ARMCANZ, [31].

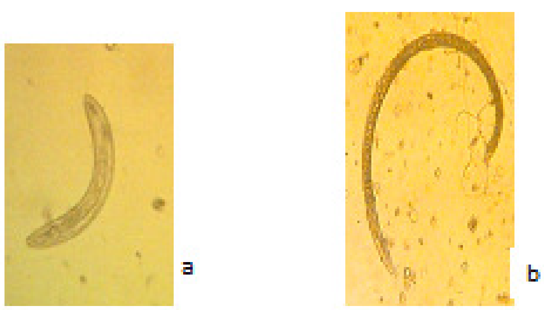

Plate 1.0. (a) Criconemoid spp, (b) Langidorus spp

4. CONCLUSION

The absence of nematode species from some parts of the river could be attributed to the long term changes in physical and biological characteristics due to flooding and dredging activities which result in very swift current in the river. Dredging removes existing nematode fauna and changes the bottom substrate of the river making it difficult for easy re-establishment of new aquatic nematode community. It was observed that the absence of aquatic nematodes species and the dominance of terrestrial nematode species and genera was due to the inflow of water into the river from the hinterland which deposit debris and suspended materials in the river. This trend of observing significant numbers of terrestrial nematode species and genera in aquatic ecosystems could be ephemeral but could be ecologically significant because it indicates pollution of an aquatic ecosystem by run-off due to heavy flooding of the hinder land.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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